

Assessing the Awareness of the General Public on the Adverse Effects of Polychlorinated Biphenyls (PCBs) on Humans and the Environment in Some Sensitive Areas of the Greater Accra Region of Ghana

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Abstract: A study was conducted to create the awareness among the general public and especially those who work directly with the transformers on the adverse health effects that are associated with the exposure to transformer oils that may contain PCBs. Knowledge of PCBs and the adverse effects on humans and the environment were assessed among Electricity Company of Ghana staff members, Volta River Authority staff members and the general public. Evidence obtained from the use of structured questionnaire analysed with Statistical Package for Social Scientist (SPSS) version 16 shows that Staff members of the technical departments of ECG/VRA (71.4%) as well as a few welders (16.7%) have come in contact with the transformer oil that may possibly contain PCBs. About 26.1% of female from ECG and VRA indicated they still work with and/or on transformer, thereby increasing the potential adverse effect associated to exposure to transformer oils that may contain PCBs. About 55.6% of the ECG/VRA staff members do not wear any protective clothing when working on transformers thus exposing themselves to PCBs. About 27.3% of the management staff members of ECG/VRA are not aware of the adverse health effects caused by PCBs.

Key words: Health effects of PCBs, PCB awareness, transformer oils

INTRODUCTION

PCBs have had an extensive industrial-use as heat exchange fluids in electric transformers and capacitors, and as additives in carbonless copy-paper, sealants and plastics due to their chemical stability. PCBs have been traded internationally under various brand names such as Kanechlor (Japan), Aroclor (USA and UK), Clophen (Germany), Chlorofen (Poland) and Phenoclor and Pylalene (France) (De Voogt and Brinkman, 1989; UNEP, 1998; UNEP, 2002a; Noma *et al.*, 2004). Their physical and chemical properties make them very stable, bioaccumulate through the food chain and are able to undergo long range atmospheric transport depending on the properties of the environment they encounter and hence have been detected in regions where they have

never been manufactured or used, (Ishikawa *et al.*, 2007; Della Valle *et al.*, 2007).

Realizing the adverse effect of PCBs and other POPs, in 2001, the Stockholm Convention was ratified with the main objective of protecting human health and the environment from the adverse effects persistent organic pollutants. The convention among other things also seeks to eliminate PCBs and other POPs by 2025. Articles 10 and 11 of the Stockholm Convention on Persistent Organic Pollutants (POPs) makes it mandatory for all parties to the convention to undertake Public information, awareness, education on PCBs among policy makers and also the general populace and also to undertake research, development and monitoring of PCBs and other POPs according to the capabilities of the state (party) (UNEP, 2002b).

Ghana has never produced PCBs but has had an extensive use of PCBs in electric capacitors and transformers for some time now. A preliminary inventory which was undertaken by the EPA (Ghana) in 2006 revealed that records were not available on the maintenance of these transformers which may contain PCBs.

Coupled with the fact that some of the technicians who undertake these maintenance works on these transformers do so carelessly, thereby exposing themselves and also the general public to the hazards associated with the exposure to PCB containing transformer oils. Hence the objective of this study is to create the awareness among the general public and especially those who work directly with the transformers on the adverse health effects that are associated with the exposure to transformer oils that may contain PCBs.

METHODOLOGY

There is the possibility that most people might not be aware of the adverse effect PCBs can have on both human health and environment notwithstanding the fact that PCBs are mainly used in transformers all over the country. There is also the possibility that due to carelessness on the part of some of these technicians who work on these transformers, they end up exposing the environment and hence human beings to the adverse effects of the content of these transformers. It is also important to note that some of these transformers are located in very sensitive areas such as schools, markets, hospitals, densely populated areas etc.

Policy makers in management of some of the institutions that are responsible for these transformers may not be aware of the health and the environmental problems PCBs may pose hence may not have proper policies for the management of these transformer oils which may contain PCBs. Ignorance of the hazards may also explain why some of these used transformer oils are being sold on the market to welders and entrepreneurs who make hair creams etc. There is therefore the need to assess the awareness of both the general public and staffs of the institutions which are directly responsible for these transformers. In achieving these objectives a structured questionnaire was designed with both close and open ended questions to collect information (data) from respondents.

Selection of areas and respondents: The study was conducted in the Accra-Tema metropolis which has a lot of these sensitive sites and more transformers than any other region. The respondents were mainly grouped into 3 categories. These were:

- Staff of ECG and VRA at all levels
- Welders
- Others which included accountants, public servants, bankers, lecturers, teachers, doctors, engineers, dressmakers, hairdressers etc.

These respondents were selected randomly and interviewed. A total of about 130 respondents were interviewed during the months of April, 2007 to May 2008.

Scope of research: The questionnaire was designed to answer very pertinent questions and also to confirm some of the issues that were identified from the preliminary inventory conducted by the Environmental Protection Agency Ghana in 2005. Among the questions that were asked included:

- Have you ever worked on/with a transformer before
- Do you still use the transformer oil
- Are you aware if people collect these transformer oil
- Have you ever come into contact with this transformer oil
- Do you think transformer oil can cause any health effect
- Do you wear any protective gear when working
- Have come into contact directly with the transformer oil before

RESULTS AND DISCUSSION

Questionnaire distribution and recovery: Table 1 shows the distribution of the questionnaires among the different professions. 60 out of the 130 questionnaires were administered to the staff of both ECG/VRA and other professions respectively. Ten questionnaires were administered to welders. About 71.7% which represent 43 out of the 60 questionnaires administered to the ECG/VRA staff were returned, whilst about 58.3% representing 35 out of the 60 questionnaires administered to the other professions were returned. The return rate on the other hand from the welders was 60% as 6 out of the 10 questionnaires administered were returned.

In all a total of 65% of the 130 questionnaires administered which represent 84 questionnaires were recovered.

Table 1: Distribution of questionnaire among the different profession (occupation)

Occupation (Profession)	Questionnaires given out	Questionnaires returned	Percentage returned
ECG/VRA	60	43	71.7
Welders	10	6	58.3
Others	60	35	60
Total	130	84	65

Table 2: Gender of respondents who have ever worked on/with a transformer

			Gender of respondents		
			Male	Female	Total
Have you ever worked on/with a transformer before?	Yes	Count	25	6	31
		% within gender respondents	80.6%	19.4%	36.9%
	No	Count	34	18	52
		% within gender respondents	65.4%	34.6%	61.9%
	No answer	Count	1	0	1
		% within gender respondents	100.0%	0.0%	1.2%
Total		Count	60	24	84
		% within gender respondents	100.0%	100.0%	100.0%

Table 3: Profession of respondents who have ever worked on and/or with a transformer

			Profession			Total
			ECG/VRA	Welders	Others	
Have you ever worked on/with a transformer before?	Yes	Count	30	0	0	30
		% within profession	71.4%	0.0%	0.0%	36.1%
	No	Count	11	6	35	52
		% within profession	100.0%	100.0%	100.0%	62.7%
	No answer	Count	1	0	0	1
		% within profession	2.4%	0.0%	0.0%	1.2%
Total		Count	42	6	35	83
		% within profession	100.0%	100.0%	100.0%	100.0%

Table 4: Gender of respondents who still work on transformer

			Gender of respondents			Total
			Male	Female		
Do you still work with transformer?	Yes	Count	22	6		28
		% within gender of respondents	78.6%	21.4%		
	No	Count	31	16		47
		% within gender of respondents				
Total		Count	53	22		75
		% within gender of respondents				

Table 5: Job classification of respondents who still work with transformers

			Classify your job				Total
			Policy	Management	Technical	Others	
Do you still work with transformers?	Yes	Count	0	4	23	1	28
		% within	0.0%	14.3%	82.1%	3.6%	
	No	Count	1	16	14	11	42
		% within					
Total		Count	2	20	37	12	70
		% within					

Table 6: Job classification of respondents who have ever worked on and/or with a transformer

			Classify your job				Total
			Policy	Management	Technical	Others	
Have you ever worked on/with a transformer before?	Yes	Count	0	6	24	1	31
		% within	0.0%	19.4%	77.4%	3.2%	40.3%
	No	Count	1	16	16	12	45
		% within	2.2%	35.6%	35.6%	26.6%	58.4%
	No answer	Count	0	0	1	0	1
		% within	0.0%	0.0%	100.0%	0.0%	1.3%
Total		Count	1	22	41	13	77
		% within					

Respondents who have worked on and/or with a transformer: Table 2 shows that thirty seven percent 36.9% representing 31 of the total respondents of 84 have worked on a transformer before and about 19% representing 6 out of this figure were females and 81% representing 25 were males.

Table 3 indicates that a total of 30 respondents who indicated their profession to have worked on and/or with transformers. These 30 respondents make up about 71% of the total ECG/VRA respondents of 42.

However, Table 4 indicates that about 21.4% of the 28 respondents who indicated their sex and still work on

Table 7: Gender of respondents who have been exposed to transformer oils

			Gender Of Respondents		
			Male	Female	Total
Did you ever Come into contact With this transformer oil?	Yes	Count	26	6	32
		% within gender of respondents	44.1%	26.1%	39.0%
	No	Count	33	17	50
		% within gender of respondents			
Total		Count	59	23	82
		% within gender of respondents			

Table 8: Profession of respondents who have come into contact with transformer oil

			Profession			
			ECG/VRA	Welders	Others	Total
Did you ever Come into contact With this transformer oil?	yes	Count	30	1	0	31
		% within profession	71.4%	16.7%	0.0%	38.3%
	No	Count	12	5	33	50
		% within profession	28.6%	83.3%	100.0%	61.7%
Total		Count	42	6	33	81
		% within profession	100.0%	100.0%	100.0%	100.0%

Table 9: Job classification of respondents who have ever exposed to transformer oil

			Classify Your Job				
			Policy	Management	Technical	Others	Total
Have you ever Come into contact With transformer Oil before?	yes	Count	0	5	24	3	32
		% within	0.0%	23.8%	60.0%	23.1%	42.7%
	No	Count	1	16	16	10	43
		% within	100.0%	76.2%	40.0%	76.9%	57.3%
Total		Count	1	21	40	13	75
		% within					

Table 10: Profession of respondents who use or do not use protective gear

			Profession			
			ECG/VRA	Welders	Others	Total
With what hands?	Bare hand	Count	15	2	0	17
		% within profession	55.6%	66.7%	0.0%	54.8%
	Wore a glove	Count	12	1	0	13
		% within profession	44.4%	33.3%	0.0%	41.9%
	Not applicable	Count	0	0	1	1
		% within profession	0.0%	0.0%	100.0%	3.2%
Total		Count	27	3	1	31
		% within profession	100.0%	100.0%	100.0%	100.0%

and/or with transformers were female from the above institutions and are possibly being exposed to PCB-based transformer oil as part of their daily duties of maintaining these transformers.

PCBs are known to be able to cross placenta into the fetus of mothers (USEPA, 2007). There is therefore the possibility of increase in the risk of exposure of these women and their infants (unborn babies) to the transformer oils that may contain PCB.

Table 5 indicates that about 82.1% of the respondents who still work with/on transformers are from the technical departments of ECG and VRA. This emphasizes the fact that mainly the technical staff of ECG and VRA and more importantly the female staff are at a higher risk of exposure to transformer oils which may contain PCBs as

a result of their daily activities of maintaining these transformers (Table 5).

The job classification of respondents who have ever worked with and/or on transformers is shown in table 6. About 77.4% of respondents who have worked on and/or with transformers described their job as technical, about 19.4% described their jobs as managerial and only 3.2% described their jobs as others (clerical, secretarial etc.). None of those who described their jobs as policy have ever worked on transformers (Table 6).

This suggests that those who are most likely to be exposed to this transformer oil that may contain PCBs are mostly the technical and a few of the managerial staff of both ECG and VRA (Table 4 and 5). The figure also

Table 11: Gender of respondents who knows transformer oil can cause adverse health effects

			Gender Of Respondents		
			Male	Female	Total
Do you know if transformer oils can cause any Health effects?	yes	Count	35	10	45
		% within gender of respondents	63.6%	52.6%	60.8%
	No	Count	18	8	26
		% within gender of respondents	32.7%	42.1%	35.1%
	Not sure	Count	2	1	3
		% within gender of respondents	3.6%	5.3%	4.2%
Total	Count	44	19	74	
	% within gender of respondents	100.0%	100.0%	100.0%	

suggest that those who described their jobs as being part of the policy category who make policies regarding safety at the work place had not worked on transformers that may contain PCBs before.

Respondents who have been exposed to transformer oils: Table 7 shows that about 44.1% of total male respondents representing about 26 out of 59 male respondents have been exposed to transformer oil. About 26.1% of total female respondents representing about 6 out of 17 females have also been exposed to transformer oil.

About 39% of the total respondents representing 32 out of 82 respondents have been exposed to transformer oil (Table 7). This is significant due to the fact that should these oils contain PCBs, they will bioaccumulate in their host thereby increasing the health risk associate with its exposure. The fact that PCBs may cross from mothers to their unborn children via the placenta (USEPA, 2007) makes it alarming.

Table 8 shows that about 71.4% representing 30 of 42 respondents from ECG and VRA staff members claim to have been exposed to transformer oils. The 30 also represent about 96.8% of the total respondents who indicated their profession as having been exposed to transformer oils that may contain PCBs. About 3.2% of the total respondents who have been exposed to transformer oils were welders. The 3.2% welders represent about 16.7% of the total welders who answered that they have been exposed to transformer oil (Table 8). ECG/VRA staff members are being exposed to these transformer oils as a result of their daily duties. There is the need to institute measures to arrest any incident.

Table 9 indicates that about 60% representing 24 of the total 40 technical staff respondents have been exposed to transformer oil that may contain PCBs. This 60% also represent about 75% of the total of 32 respondents who responded to have been exposed to transformer oil that may contain PCBs. About 23.8% of total managerial staff representing about 15.6% of the total respondents had also come into contact with transformer oils that may contain

PCBs (Table 9). Those mainly at risk are therefore the technical staff members of both ECG and VRA. This is due to the fact that as part of their daily duties, they find themselves working on these transformers and its contents.

Respondents who use personal protective clothing: Table 10 shows that about 55.6% of the total of 27 ECG/VRA respondents used their bare hands (unprotected) when working on these transformer oils which may contain PCBs. About 66.7% of welders also did not use protective clothing when working. This is a dangerous practice that must be addressed urgently to prevent exposing the staff members of ECG/VRA to the adverse health effects associated with exposure to PCB containing transformers. It is therefore very important that to reduce risks of exposure it should be made mandatory to use protective clothing.

Respondents who know transformer oil can cause adverse human health effects: Table 11 shows that about 60.8% of the total respondents said they were aware of the possible adverse health effect caused by transformer oils that may contain PCBs, whilst 35.1% responded they were not aware of the possible adverse health effects posed by PCB-based transformer oil. 4.1% were not sure transformer oil that contained PCBs could cause adverse health effect. About 42.1% of the total female respondents had no knowledge of the possibility of transformer oil that contained PCBs to cause adverse health effect. About 5.3% of the total female were also not sure that transformer oil that contained PCBs causes adverse health effects.

From the responses obtained, a total of about 39.2% representing about 29 of the total respondents were either not aware or not sure transformer oils that contained PCBs could cause adverse health effect (Table 11). This may mean that a significant section of the population may

Table 12: Job classification of ECG and VRA respondents who knows transformer oil can cause adverse health effect

	Management	Technical	Others
Yes	72.7 (8)	78.6 (22)	25 (1)
No	27.3 (3)	21.4 (6)	75 (3)

Table 13: Profession of respondents who knows if transformer oils can cause any health effects

			Profession			
			ECG/VRA	Welders	Others	Total
Do you know if Transformer oils can Cause any health effects?	Yes	Count	30	3	11	44
		% within profession	85.7%	50.0%	34.4%	60.3%
	No	Count	5	2	19	26
		% within profession	14.3%	33.3%	59.4%	35.6%
	Not sure	Count	0	1	2	3
		% within profession	0.0%	16.7%	6.3%	4.1%
Total		Count	35	6	32	73
		% within profession	100.0%	100.0%	100.0%	100.0%

Table 14: Profession of respondents who believe people unofficially collect the oil

			Profession			
			ECG/VRA	Welders	Others	Total
Are you aware People collect this Transformer oil?	Yes	Count	21	1	1	23
		% within profession	51.72%	25.0%	3.2%	30.3%
	No	Count	20	3	30	53
		% within profession	48.8%	75.0%	96.8%	69.7%
Total		Count	41	4	31	76
		% within profession	100.0%	100.0%	100.0%	100.0%

Table 15: Profession of respondents who know where transformer oil could be bought

			Profession			
			ECG/VRA	Welders	Others	Total
Do you know where It could be bought?	Yes	Count	10	3	0	13
		% within profession	76.9%	23.1%	0.0%	18.1%
	No	Count	27	2	30	59
		% within profession	45.8%	3.4%	50.8%	81.9%
Total		Count	37	5	30	72
		% within profession				

not be aware of the health risks transformers containing PCBs may pose. There is therefore the need for effective educational campaign to bridge the gap and hence reduce the extent of exposure to PCB-based transformer oils.

Table 12 indicates that a total of about 85.7% representing 30 of the total ECG/VRA staff members were aware of the health impacts that transformer oils containing PCB poses. 50% and about 34.4% respectively of total welders and other professions were also aware of the adverse health effects of PCBs.

Analysis conducted on only ECG/VRA respondents showed from table 12 that:

- 27.3% of the respondents in management were not aware of the adverse health effect of PCB
- 21.4% of technicians were also not aware of the effects of PCB
- 75% of the other staffs of ECG/VRA were not aware of the adverse health effect of PCBs

Although about 72.7% of the management (including those who make policies at both ECG and VRA) respondents were aware of the adverse health effects of PCBs, a significant number making up about 27.3% were also not aware (Table 12). This poses a major problem when decisions (policies) have to be made on the management of PCB containing transformers. It is

therefore important that all management should be educated on both the health and environmental impact PCBs poses.

About 21.4% of technicians were also not aware of the adverse health impacts of PCBs. The technicians are directly responsible for the maintenance and the day to day running of these transformers. There is the need to educate all technicians and most especially the other staff of the two institutions on both the environmental and adverse health effects of PCBs

From the Table 13, it could be inferred that about 59.4% of respondents from the other professions were not aware and about 6.3% were not sure of the health effect PCB-containing transformer oils may pose. This therefore underscores the need to have training (educational) programs organized regularly to sensitize the general public in particular and also ECG/VRA and the welders on the health effects of transformer oils containing PCBs and how to minimize exposure to them.

Respondents who Believe Transformer Oils Are Collected Unofficially By both ECG/VRA and non ECG/VRA staffs: From Table 14 shown below, about 51.2% of the total of 41 respondents from ECG and VRA staff members answered that they believed people unofficially collected these transformer oils. 25% of total welders and about 3.2% of total other professions also

believed that people unofficially collected these transformer oils that may contain PCBs.

The total ECG and VRA staff members who responded of believing people unofficially collected these transformer oils formed about 91.5%, representing 21 out of the 23 total respondents who believed people unofficially collected transformer oils that could contain PCBs.

This increases the risk of the possibility that these transformer oils may go into the hands of unqualified persons thereby increasing the risk of exposure of the general public to PCBs and hence its associated health effects.

Access to all transformers is supposed to be restricted, however, this is not so in practice, hence intruders are able to access and tamper with the transformer and its content including the oil.

Respondents who know where transformer oils could be bought: Table 15 shows that 76.9% representing 10 out of the 13 total respondents who know where transformer oils could be bought are ECG and VRA staff members. 23.1% of welders who make up about 60% of the total welder respondents also indicated of knowing where to buy the used transformer oils. Significantly, those from the other professions did not know where to buy these transformer oils.

The final report from EPA, revealed that the waste tanks at the ECG office which is supposed to house the used transformer oils has never been full. Informal interaction with some ECG staff also indicated that siphoning of these transformer oils by some of the staff was a major problem as some have been caught in the act and dismissed.

Interactions with some of the welders also indicated that they buy these used oil from the timber market in Accra and were actually willing to assist the investigator buy some.

CONCLUSION

The following are the conclusions drawn from the results obtained from this research.

Mostly the technical staff of ECG and VRA work on these transformers and that mainly those in this group know about the components and also the materials used as insulators in these transformers.

It was also clear from the results that mostly the staffs in the technical departments of ECG/VRA (71.4%) as well as a few of the welders (16.7%) had come directly into contact with the transformer oil as part of their daily activities and are therefore likely to have been exposed to PCBs.

However most of these technical staff (55.6%) does not wear any protective gears when working on these transformers, hence increasing the possibility of exposure to transformer oils to those in this job category which include both male and females.

Knowledge of the potential of transformer oil to cause ill health is relatively higher among ECG/VRA staff (85.7%) than other professions (50% for welders and 34.4% for others) and most importantly higher among the technical staff (67.2%). However, their working culture (not using protective gears) exposes them to the potential hazards associated with exposure to these transformer oils.

ACKNOWLEDGMENT

The authors wish to thank the technicians and staff of Electricity Company of Ghana, Volta River Authority and Organic Residues Laboratory of Ghana Atomic Energy Commission for their help and support of the present study.

REFERENCES

- Della Valle, M., E. Codato and A. Marcomini, 2007. Climate change influence on POPs distribution and fate: A case study. *Chemosphere*, 67: 1287-1295.
- De Voogt, P. and U.A.T.H. Brinkman, 1989. In: Kimbrough, R.D. and A.A. Jensen, (Eds.), *Halogenated Biphenyls, Terphenyls, Naphthalenes, Dibenzodioxons and Related Products*. Elsevier, Amsterdam (Chapter 1).
- Ishikawa, Y., N. Yukio, M. Yoshihito, S. Shin-Ichi, 2007. Congener profiles of PCB and a proposed new set of indicator congeners. *Chemosphere*, 67: 1838-1851.
- Noma, Y., Y. Ishikawa, K. Nose, K. Minetomatsu, H. Takigami and S. Sakai, 2004. Chemical characterization of PCB and dioxins in the waste PCB stockpiles. *J. Environ. Chem.*, 14: 501-518.
- UNEP (United Nations Environment Programme), 1998. *Inventory of World-Wide PCB Destruction Capacity*, Geneva, Switzerland.
- UNEP (United Nations Environment Programme), 2002a. *Ridding the World of POPs: A Guide to the Stockholm Convention on Persistent Organic Pollutants*. Geneva, Switzerland.
- UNEP (United Nations Environment Programme), 2002b. *Stockholm Convention on Persistent Organic Pollutants*, Geneva, Switzerland.
- USEPA, 2007. *Mid-cycle Pec Review ORD's Human Health Research Program*. United States Environmental Protection Agency, 24 January.